View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

N94-16363

EXPERIMENTALLY REPRODUCED RELICT ENSTATITE IN PORPHYRITIC CHONDRULES OF ENSTATITE CHONDRITE COMPOSITION; Gary E. Lofgren, John M. DeHart, Code SN4, NASA-Johnson Space Center, Houston, TX 77058; Tammy L. Dickinson, Code SLC, NASA Headquarters, Washington DC, 20546.

We recently proposed a model for the origin of porphyritic pyroxene (PP) chondrules in enstatite chondrites that contain phenocrysts of enstatite with blue cathodoluminescence (CL) set in a matrix of radial, dendritic enstatite with red CL [1]. The model is based upon studies of chondrules in ordinary chondrites [2] which suggest that they form as mechanical aggregates of crystalline and other material that are then partially melted and cooled. When melting is essentially complete so that only submicroscopic nuclei remain, the texture that forms is porphyritic and all the phenocrysts will be newly formed with virtually undetectable relict cores. If melting is significantly less complete, however, relatively large relict crystals will remain. Such relict crystals were first described in chondrules in enstatite chondrites by [3,4] and identified by their distinctly different CL and chemistry compared with the dominant crystals in the chondrule. In this case the pyroxene phenocrysts which we consider relict have distinctive levels of Mn and Cr and Al which produce a characteristic blue CL. We have completed experiments in which previously grown blue CL En (relict) is enclosed in a matrix of red CL En with a coarsely radial texture.

Our proposed history begins with the mechanical aggregation of i) nearly pure enstatite (i.e. low in Mn, Cr, and Al) which typically has blue CL, ii) enstatite with increased levels of these minor elements which typically has red CL, iii) sulfides, iv) Fe-metal, and v) other minor phases. This aggregate is then partially melted so that some of the blue CL enstatite, presumably initially coarser grained, is preserved. The chondrule is then cooled quite rapidly and the remaining melt crystallizes to a radial texture. The radial texture would develop only if the remaining melt in the chondrule is free of nuclei at the beginning of cooling. Nucleation would then occur on embryos which become nuclei during the cooling [5]. The Mn, Cr, and Al in the radial enstatite could come from melted red Cl enstatite in the aggregate or from the sulfides and other minor phases, if no red CL enstatite was aggregated. During the rapid growth necessary to produce the radial texture, the minor elements would be readily incorporated into the newly grown enstatite producing the red CL. If nuclei are preserved in the melt surrounding the relict blue CL enstatite, the matrix will be microporphyritic to even porporphritic.

We have conducted experiments to test this model using established one-atmosphere, gas-mixing techniques [6]. Enstatite crystals that give off blue CL were grown from a very pure melt of enstatite composition. Several large crystals (up to 1 mm in diameter) were added to the standard enstatite chondrule starting material [7] that contained significant quantities of Mn, Cr, and Al. The few enstatite crystals added only a few micrograms to a charge of approximately 100 micrograms. This charge was melted for 20 to 45 minutes at 1537°C, a temperature slightly below the liquidus of the melt so as not to completely melt the pure, blue CL enstatites. The appropriate melt temperataure will vary with the size of the crystals and the liquidus temperature of the specific melt composition. The run was then cooled at 1000°C/hr in attempt to duplicate the typical matrix texture. We were successful in producing relict enstatite phenocrysts with blue CL in a matrix of coarsely radial to dendritic enstatite with red CL.

The relict crystals are preserved in runs with a melt time of 36 minutes or less at 1537°C. The relicts remain angular with smooth crystal/melt interfaces (Fig. 1). There are no embayments as suggested by [8] along the crystal/melt interfaces, and thus melting has occured uniformly. Partial melting does occur along fractures produced when the blue CL enstatite was initially grown and cooled through the proto/ortho enstatite transition with the attendent volume change. There is either reaction with the melt and diffusion of Mn and Cr into the blue CL En, or there is an overgrowth of red CL En along the fractures (Fig. 1). The bulk of the relicts remain blue. The melt enclosing the relicts crystalized to a coarsely radial to dendritic to microporhyritic texture comprised of enstatite that has a bright red CL with decreasing melt time. The blue CL En has Mn and Cr contents at or below detection limits of the electron probe as described in earlier studies [9] and in natural blue Cl En [1]. In the red CL En in this study, the Mn, Al2O3, and Cr are at levels observed in [9] and the levels change rapidly also as observed in [9].

These experiments show that our model appears feasible. Relict crystals with Blue CL can survive a brief melting period and retain the blue CL with very modest reaction while enstatite with red CL will crystallize from the surrounding melt. The melting textures are not totally reminscent of natural chondrules, as the real relict En appear to have been annealed and do not show the inversion fracturing. Unfortunately we did not have the time to anneal the En crystals to such a condition. No embayments were observed in the relicts in the experiments, a problem raised by [8] to negate the partial melting origin. A similar senario could work for olivine. The variable matrix textures in the experiments correlate well with similar textures observed in natural chondrules. Leitch and Smith [8] studied chondrules with radial matricies, but we have observed many with microporphyritic textures. We can conclude that the physical process that form EC chondrules is basically the same as OC chondrules. The differences are in both the redox conditions and the bulk composition. If metamorphism is an important process in the formation of these EC chondrules, it occurs early before aggregation of materials which are then melted to form chondrules as suggested by [10]. These studies also show that enstatite can grow from igneous melts given the right nucleation conditions.

REFERENCES: [1] Lofgren et al. (1992) Lunar and Planetary Science XXIII, Lunar and Planetary Institute, Houston, 801-802. [2] Hewins (1988) in *Meteorites and the Early Solar System*, Kerridge and Matthews eds, 660-679. [3] Nagahara (1981) Nature **292**, 136. [4] Rambaldi (1981) Nature **293**, 558-561. [5] Lofgren (1983) J. Petrol. **24**, 229-255. [6] Lofgren and Russell (1986) GCA **50**, 1715-1726. Lofgren (1989) GCA **53**,461-470. [7] Lofgren et al. (1991) Meteoritics, **26**, 366-367. [8] Leitch and Smith (1982) GCA **46**, 2083-2097. [9] Lofgren and Dehart (1992) Lunar and Planetary Science XXIII, Lunar and Planetary Institute, Houston, 799-800. [10] McKinley et al. (1984) LPSC 14, JGR **89**, Suppl. B567-B572.

Fig. 1: A black and white photograph of a colar CL image. The light area labeled bl is blue CL enstatite and the dark gray area labeled rd is the red CL enstatite. The dark lines in the light (bl) area are the fractures with red CL. The width of the photograph is 250 micrometers.